Demonstration of DeconGel™ at the Oak Ridge National Laboratory Building 2026

Final Report

Demonstrated at:
Radioactive Materials Analytical Laboratory (RMAL) Building 2026
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Prepared for:
U.S. Department of Energy
Environmental Management Program
Office of Deactivation and Decommissioning and Facility Engineering (EM-23)

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Executive Summary

DeconGel™ from Cellular Bioengineering Inc. was demonstrated for removal of alpha and beta contamination from a spill of low level liquid waste in Building 2026 at Oak Ridge National Laboratory. Some of the areas had been previously treated with a clear lacquer coating and stabilized with Contamination Control Wetting Agent (CCWet). DeconGel™ was effectively applied to floor, wall, door, and track areas in Room 120 of Building 2026. In the initial application of DeconGel™, alpha transferable contamination levels were reduced by 51% and beta transferable contamination levels by 58%. For the floor, door, and wall samples 53% of the alpha and 82% of the beta contamination was removed. However, some track areas showed increased beta contamination that likely resulted from the release of debris or removal of prior stabilizing agents by the DeconGel™. A second application of DeconGel™ to the tracks reduced the alpha contamination by 38% and the beta by 63%. The effect of previous treatment processes on the efficacy of the tested gels in this demonstration is still unclear. Additional testing will be conducted at other DOE sites to better define the variables influencing the efficacy of the gels.

Background

The Radioactive Materials Analytical Laboratory (RMAL), Building 2026 at Oak Ridge National Laboratory (ORNL) was built in 1964, with additions constructed in 1966 and 1985 (Figure 1). The facility provided a wide range of analytical chemistry and research and development support activities involving a broad range of physical, chemical, and radiochemical measurements on radioactive materials. The building is a nuclear Hazard Category 3 facility (ORNL, 2007).

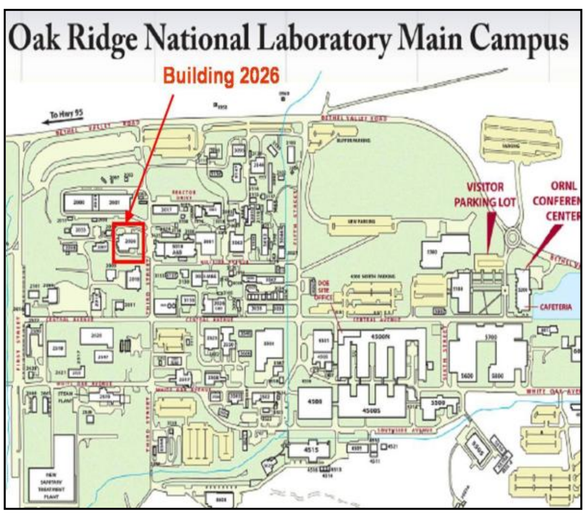


Figure 1A. Location Map of ORNL

Figure 1B. Building 2026 East Entrance

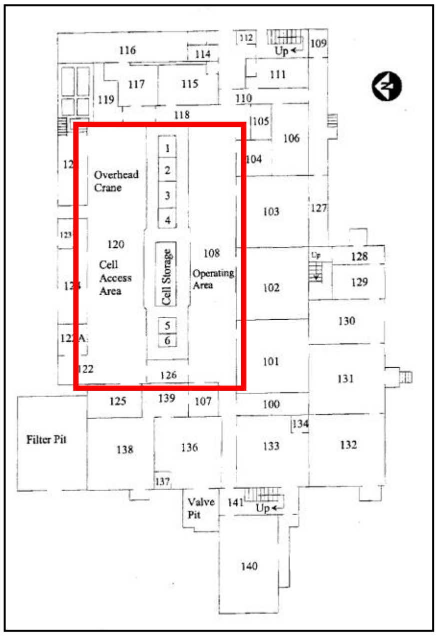


Figure 2A. Plan View of Floor 1 of Building 2026 (ORNL, 2007)

Figure 2B. Building 2026 Room 120 Hot Cell Area showing door tracks

The first floor of the facility contains six manipulator hot cells (Figure 2). The cell access area, mechanical conveyors, and overhead crane are located immediately adjacent to the hot cells in Room 120.

On October 6, 2003, ORNL personnel were conducting waste operations in hot cell 1 of Building 2026 using manipulators to remotely denature, dilute, and dispose of low level liquid waste (LLLW) into the Bethel Valley LLLW system. The waste contained about 38 grams of plutonium and 2 grams of americium. The denatured liquid was poured into a drain line fixed to an upper cell pan which was visible from the hot cell window. The line then passed through a lower pan (not visible from the hot cell window) and then into a waste storage tank located outside of Building 2026. This denatured liquid was flushed with about 5-gallons of process water. After this flush, process water in the hot cell was run for about 30 minutes at a flow rate of about 1 gallon/minute. During the waste disposal and subsequent flushing, the drain was partially plugged. As a result, the liquid filled the lower cell pan in one or more of the hot cells and then flowed under the cell doors into Room 120. There was no evidence of airborne activity (Flynn, 2003).

The spill in Room 120 resulted in high levels of removable alpha and beta contamination in the general area behind Cells 1, 2, and 3. Smear surveys taken after the discovery of the spill showed alpha contamination levels ranging from 1800 dpm/100cm^2 to 2.5E+06 dpm/100cm^2 and beta removable contamination ranging from 600 dpm/100cm^2 to 1.1E+06 dpm/100cm^2.

A long-term recovery plan was developed which involved investigating, troubleshooting, and remediating the drain malfunction. After the cell drains had been cleared, decontamination efforts began in Room 120. Several decontamination evolutions were performed. However, the removable contamination levels in the cell access area remained high. This, in turn, resulted in the area being posted as a High Contamination Area, Radiation Area, and Airborne Radioactivity Area.

Later in 2003, a clear lacquer coating was applied to stabilize the high level of contamination that was in the cell tracks. In 2007, a coating of Contamination Control Wetting Agent (CCWet) was applied over all horizontal surfaces and from three to five feet up the walls to minimize airborne contamination. CCWet is a water-based spray-on product used to reduce airborne contamination, and has been previously used to reduce airborne contamination in radiological applications. The product wets, penetrates and causes particles to adhere to the surface and prevents airborne release. Over the past two years ORNL has continued to apply CCWet to areas that have been disturbed.

Technical Need Description

The Department of Energy (DOE) Environmental Management Program, Office of Deactivation and Decommissioning and Facility Engineering (EM-23) uses an integrated systems approach to develop, test, and demonstrate a suite of innovative deactivation and decommissioning (D&D) technologies (D&D Toolbox) to be readily used across the DOE complex to reduce technical risks, improve safety and limit uncertainty within D&D operations. This project is part of an effort to demonstrate D&D technologies at high risk facilities at ORNL for the benefit of D&D activities at other structures that are part of the Integrated Facilities Disposition Project (IFDP) effort.

Decontamination gels are designed to be applied (painted, sprayed, etc.) to contaminated surfaces, allowed to dry, and then be removed along with varying levels of the original contaminant depending on factors such as surface conditions, type of contaminants, contaminant-substrate, and contaminant-gel interactions. As part of the D&D Toolbox, EM-23 is evaluating different decontamination agents on various media and contaminants. For the first demonstration of decontamination agents at ORNL a decontamination gel manufactured by Cellular Bioengineering Inc. (CBI) was chosen for demonstration in the contaminated area behind the hot cells in ORNL Building 2026.

The CBI gels were tested at ORNL through a grant between the Department of Energy Office of Environmental Management and CBI, and managed by the EM-23.

Technology Description

CBI Polymers is a division of Cellular Bioengineering, Inc. (CBI), a venture accelerator focused on biomedical and biodefense applications. Laboratory testing and early field demonstrations of DeconGel™ have indicated a high affinity for the removal of radioactive contamination. CBI has developed decontamination gels (DeconGel™ 1101, 1120, and 1121) that when dried allow efficient removal as a strippable film that can be easily disposed (Figure 3). CBI recommends the gels for decontamination of radioisotopes as well as particulates, heavy metals, water soluble and insoluble organic compounds (including tritiated compounds). The hydrogel coating can be applied to horizontal, vertical and inverted surfaces, and can be applied to most substrates including bare, coated and painted concrete, aluminum, steel, lead, rubber, plexiglass, herculite, wood, porcelain, tile grout, and vinyl, ceramic and linoleum floor tiles. When dry, the product is designed to lock the contaminants into a polymer matrix. The film containing the encapsulated contamination can then be peeled and disposed of according to appropriate local, state, and federal regulations.

Figure 3. Worker removing DeconGel™ during non-ORNL Application
(Photo supplied by CBI)

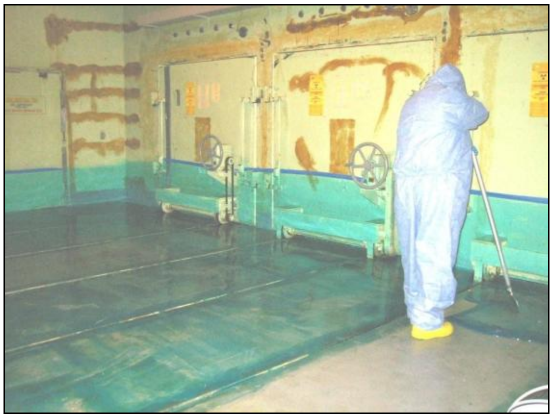
DeconGel™ 1101 is a gel form of the product designed to be applied by brush, trowel or roller. DeconGel™ 1121 is a spray form of the product designed to be applied by an industrial airless sprayer.

Previous DOE sponsored field tests included the decontamination of Pu-238 in highly contaminated glove boxes with DeconGel™ at Lawrence Livermore National Laboratories (Sutton et al., 2008). Surfaces decontaminated in this test included aluminum, cast steel and Lexan (polycarbonate) windows. The average decontamination efficiency after three applications was 99+% and the gel shielded 91+% of the radiation during drying. Given the highly contaminated nature of the glove boxes, the decontamination efficiency was considered excellent, and it was estimated that a significant savings in man hours was realized.

A second field test included the decontamination of multiple surfaces with DeconGel™ at Alaron Nuclear Services. The average reduction in loose beta activity was 90-100%. Isotopes decontaminated include Cs-137, Cs-134, Co-58, Co-60, Mn-54, Fe-55, Ni-63, Ni-59, Zn-65, Zr-95, U-238, U-234, U-235, Ag-110m, Zn-65 and Sr-90. Highlights of single applications include: a 90% reduction of loose beta contamination on the cylindrical surface of a Nuclear Assurance Corporation (NAC) National Lead Industry (NLI) storage cask, a 98% reduction of loose beta contamination on the soiled cap of an NAC NLI storage cask, and a 99% reduction of loose beta contamination on the bare concrete floor of the heavily used contaminated area (Otlowski et al., 2008).

Project Execution

In the initial application of DeconGel™ in ORNL Building 2026 on January 29 and 30, 2009, 25 gallons (total for 1st and 2nd applications and brush application to doors) of DeconGel™ 1101 were applied by paintbrush, a 3/16” V tooth trowel, and a Standing Notch Trowel Kit with a ¼ X 1/8 X ¼ square blade, and 6.5 gallons of DeconGel™ 1121 was applied using a GRACO Ultramax II 795 airless sprayer. On January 29 DeconGel™ was applied approximately four feet up on the east wall of Room 120 to approximately one foot past the cell 3 door, approximately four feet up the north wall, and approximately four feet up the cell bank from the floor surface. On January 30, 2009 a second layer was applied to the same area, and a first layer applied to six approximately 45” by 25’ floor sections north of the cell doors. The gel was allowed to dry over the weekend and removed on Monday, February 2, 2009.



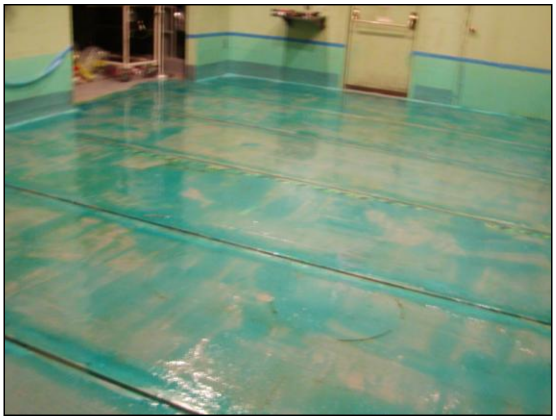


Figure 4. First Application of DeconGel™ in Room 120

Prior to the first application of DeconGel™, the door tracks, which contained some debris, had been treated with lacquer and CCWet. Because radiological survey data (Table 1) showed that the contamination readings increased after application and removal of the gel, it was postulated that the DeconGel™ may have pulled up this earlier treatment material and exposed the underlying contamination. Therefore a second application of DeconGel™ 1101 was made to the tracks on February 4, 2009 and removed on February 6 (Table 3). Retail value of the DeconGel™ used in the trial was approximately $4,725.

Figure 5. Second application of DeconGel™ to door tracks of Room 120.

Results

Swipe samples for removable contamination were taken on the walls, cell doors, floor, and tracks both before application and after removal of the DeconGel™. Samples were collected with 10 cm^2 cloth swipes and analyzed with Bicron portable alpha, beta, and ion chamber survey instruments and when contamination levels were low enough, a Ludlum Model 3030 Alpha/Beta Radiation Sample Counter. The results of the survey taken before and after the initial application are shown in Table 1.

Table 1A Smear Number	Location	Before Decon in dpm/100cm^2		After Decon in dpm/100cm^2		% Difference	
		α	β	α	β	α	β
1	North Wall	675	1000	64	NDA	91	100
2	North Wall	875	2000	162	NDA	81	100
3	North Wall	945	1000	59	NDA	94	100
4	North Wall	99	1140	67	NDA	32	100
5	East Wall	NDA	400	36	NDA	N/A	100
6	East Wall	704	1200	NDA	NDA	100	100
7	East Wall	NDA	NDA	45	NDA	N/A	N/A
8	East Wall	616	600	28	NDA	95	100
9	East Wall	203	300	NDA	NDA	100	100
10	Cell 1 Door	264	500	112	NDA	58	100
11	Cell 1 Door	3510	8000	361	326	90	96
12	Cell 2 Door	242	400	76	NDA	69	100
13	Cell 2 Door	2160	1800	115	207	95	89
14	Cell 3 Door	682	300	120	NDA	82	100
15	Cell 3 Door	4725	12,000	92	429	98	96
16	Floor NE Corner to SE Corner	2700	1700	17,181	34,728	-536	-1943
17	Floor NE Corner to SE Corner	4455	10,000	5222	8828	-17	12
18	Floor NE Corner to SE Corner	5500	9000	692	1132	87	87
19	Floor NE Corner to SE Corner	8100	21,000	16,806	32,708	-107	-56
20	Floor Between Tracks North to Cell 1 Door	11,550	20,000	1168	2109	90	89
21	Floor Between Tracks North to Cell 1 Door	3375	16,000	3570	7585	-6	53
22	Floor Between Tracks North to Cell 1 Door	7172	25,000	7717	5839	-8	77
23	Floor Between Tracks North to Cell 1 Door	6750	18,000	3704	4773	45	73
24	Floor Between Cells 1 & 2 North to Cell 1 Door	5775	10,000	12,687	14,578	-120	-46
25	Floor Between Cells 1 & 2 North to Cell 1 Door	9450	13,000	3962	4447	58	66
26	Floor Between Cells 1 & 2 North to Cell 1 Door	7590	28,000	2722	4403	64	84
27	Floor Between Tracks Cell 2 Door going North	12,150	25,000	2103	2494	83	90
28	Floor Between Tracks Cell 2 Door going North	3300	11,000	3478	4129	-5	62

Table 1A Smear Number	Location	Before Decon in dpm/100cm^2		After Decon in dpm/100cm^2		% Difference	
		α	β	α	β	α	β
29	Floor Between Tracks Cell 2 Door going North	9450	31,000	NDA	17,390	100	44
30	Floor Between Tracks Cell 2 Door going North	8404	25,000	2080	2139	75	91
31	Floor Between Cells 2 & 3 Cell 2 Door going North	18,900	60,000	1711	2142	91	96
32	Floor Between Cells 2 & 3 Cell 2 Door going North	10,450	28,000	4220	4706	60	83
33	Floor Between Cells 2 & 3 Cell 2 Door going North	1755	40,000	4194	4077	-139	90
34	Floor Between Tracks North to Cell 3 Door	22,660	84,000	1414	1843	94	98
35	Floor Between Tracks North to Cell 3 Door	6750	12,000	2422	2375	64	80
36	Floor Between Tracks North to Cell 3 Door	14,795	108,000	15,764	12,173	-7	89
37	Floor Between Tracks North to Cell 3 Door	4995	210,000	NDA	644	100	99
38	Floor West Side of Cell 3 Tracks North to South	42,460	168,000	997	821	98	99
39	Floor West Side of Cell 3 Tracks North to South	5535	14,000	NDA	1347	100	90
40	Floor West Side of Cell 3 Tracks North to South	4950	13,000	6717	8258	-36	36
41	Floor West Side of Cell 3 Tracks North to South	6750	7,000	134	740	98	89

Overall, the alpha transferable contamination levels were reduced by 51% and beta transferable contamination levels by 58% in initial treatment (Table 1A). For the floor, door, and wall samples 53% of the alpha and 82% of the beta contamination was removed. However, some samples, particularly the tracks for cells 1-3, showed increased contamination levels after the decontamination (Table 1B).

Table 1B Smear Number	Location	Before Decon in dpm/100cm^2		After Decon in dpm/100cm^2		% Difference	
		α	β	α	β	α	β
42	East Track Cell 1	990	3,200	2932	4,351	-196	-36
43	East Track Cell 1	3105	4,000	4617	3,685	-48	8
44	East Track Cell 1	64,031	33,000	7560	11,566	88	65
45	West Track Cell 1	40,500	17,000	4393	4,240	89	75
46	West Track Cell 1	15,950	90,000	NDA	12,232	100	86
47	West Track Cell 1	2430	16,000	87,884	100,455	-3517	-528
48	East Track Cell 2	20,250	13,000	25,581	23,865	-26	-84
49	East Track Cell 2	12,150	14,000	14,616	25,160	-20	-80
50	East Track Cell 2	13,500	22,000	28,804	115,307	-113	-424
51	West Track Cell 2	14,520	10,000	3618	7,114	75	29
52	West Track Cell 2	24,805	17,000	7487	10,900	70	36
53	West Track Cell 2	54,000	31,000	6507	12,462	88	60
54	East Track Cell 3	104,500	70,000	NDA	13,350	100	81

Table 1B Smear Number	Location	Before Decon in dpm/100cm^2		After Decon in dpm/100cm^2		% Difference	
		α	β	α	β	α	β
55	East Track Cell 3	41,850	25,000	19,200	62,619	54	-150
56	East Track Cell 3	94,270	70,000	14,610	8,540	85	88
57	West Track Cell 3	3375	13,000	13,854	11,544	-310	11
58	West Track Cell 3	1430	300	12,975	12,817	-807	-4172
59	West Track Cell 3	1350	700	5208	4,536	-286	-548

The increase in beta contamination levels for some sample sites, the overall high contamination levels for the track areas, and the high variability in the removal rates in the tracks most likely result from a combination of factors, such as cross contamination from adjacent areas that were not well bounded from the demonstration area, removal of surface material such as lacquer, CCWet, rust or oily residue that had previously hidden contamination and from pulling contamination from under concealed areas such as a cell door wheel. Although there was an effort to remove debris from the tracks using brushes prior to application, the effort was only partially successful. However, even in the track areas, the initial application of DeconGel™ removed 51% of the alpha contamination for cells 1-3.

Because of the mixed results from the first application in the track area, a second application of DeconGel™ 1101 was performed on the stainless steel cell door tracks on February 4, 2009. In an effort to better determine the effectiveness of the decontamination efforts, more extensive before and after smear surveys were performed (Table 2).

Table 2 Smear Number	Location	Before 2nd Decon in dpm/100cm2		After Decon in dpm/100cm2		% Difference	
		α	β	α	β	α	β
1	East Track Cell 1	60,500	44,000	11,000	6,000	82	86
2	East Track Cell 1	15,400	10,000	8800	1,000	43	90
3	East Track Cell 1	12,100	10,000	3080	11,000	75	-10
4	East Track Cell 1	6,600	5,000	3740	2,300	43	54
5	East Track Cell 1	11,000	7,000	5500	2,800	50	60
6	West Track Cell 1	8,800	8,000	9900	4,800	-13	40
7	West Track Cell 1	55,000	37,000	11,000	6,800	80	82
8	West Track Cell 1	22,000	17,000	46,200	25,800	-110	-52
9	West Track Cell 1	27,500	28,000	66,000	28,800	-140	-3
10	West Track Cell 1	110,000	60,000	66,000	35,800	40	40
11	East Track Cell 2	3,375	22,000	25,300	13,800	-650	37
12	East Track Cell 2	229,500	110,000	77,000	40,000	66	64
13	East Track Cell 2	81,000	60,000	29,700	12,800	63	79

Table 2 Smear Number	Location	Before 2nd Decon in dpm/100cm2		After Decon in dpm/100cm2		% Difference	
		α	β	α	β	α	β
14	East Track Cell 2	25,650	150,000	11,000	11,800	57	92
15	East Track Cell 2	81,000	50,000	25,300	3,800	69	92
16	West Track Cell 2	148,500	100,000	121,000	9,800	19	90
17	West Track Cell 2	43,200	35,000	24,200	45,000	44	-29
18	West Track Cell 2	94,500	42,000	36,300	27,000	62	36
19	West Track Cell 2	108,000	60,000	110,000	33,000	-2	45
20	West Track Cell 2	121,500	70,000	25,300	11,000	79	84
21	East Track Cell 3	45,900	30,000	9900	2,200	78	93
22	East Track Cell 3	31,050	19,000	220,000	60,000	-608	-216
23	East Track Cell 3	176,000	130,000	8800	2,800	95	98
24	East Track Cell 3	27,000	17,000	25,300	13,000	6	24
25	East Track Cell 3	48,600	31,000	15,400	4,800	68	85
26	West Track Cell 3	24,300	12,000	6600	2,800	73	77
27	West Track Cell 3	10,800	17,000	5500	1,400	49	92
28	West Track Cell 3	18,900	14,000	16,500	7,800	13	44
29	West Track Cell 3	24,300	15,000	18,700	15,000	23	0
30	West Track Cell 3	32,400	27,000	13,200	8,800	59	67

The second decontamination reduced the alpha contamination by 38% and the beta by 63%. A small number of samples showed increased alpha and/or beta contamination after the second application. The role previous treatment processes played in this field test, as it relates to the efficacy of the tested gels, is still unclear.

Smear samples with the highest readings taken prior to each of the two DeconGel™ applications were sent to the Radiochemical Engineering Development Center Laboratory at ORNL for isotopic analysis. Two strips, approximately 9 inches long and ½ inches wide, of the most highly contaminated DeconGel™ film were cut after removal and also analyzed. The results are shown in Table 3. The reason for the increase in readings between applications one and two and for the order of magnitude difference increase in the DeconGel™ is uncertain. However, high levels of alpha contamination as well as plutonium and americium in the removed gel samples confirm that DeconGel™ was effective in removing contamination.

Table 3 Isotopic Analysis	Application #1 (BQ)	Application #2 Tracks (BQ)	From Gel (BQ)
Gross alpha	1,500 ± 240	6,800 ± 500	61,000 ± 1,800
5.15 MeV Pu-239/240	288 ± 46	768 ± 56.5	10,675 ± 315
5.30MeV U-232	108 ± 17		
5.50MeV Pu-238/Am-241	693 ± 111	2176 ± 160	50,325 ± 1485
5.70MeV Ra-224	111 ± 18		
5.80MeV Cm-244		3,856 ± 283.5	
6.30MeV Rn-220	112.5 ± 18		
6.80MeV Po-216	109.5 ± 17.5		
8.80MeV Po-212	78 ± 12.5		

DeconGel™ contains 4% ethyl alcohol as well as other chemicals. Baseline monitoring for personnel exposure to ethyl alcohol and lower explosive limit was conducted on both days of the initial application. During day one, four samples were taken, all well below the ACGIH TLV-TWA and OSHA Personnel Exposure Limit of 1,000 ppm for ethyl alcohol. During Day 2 a level of 500 ppm was measured at the time personnel were completing application to the floor area.

Conclusions/Lessons Learned

DeconGel™ was effectively applied to floor, wall, door, and track areas in Room 120 of Building 2026 at ORNL. The initial application of DeconGel™ was successful in removing approximately 50% of the contamination from floors, walls and doors. However, some track areas showed increased beta contamination that likely results from the release of debris or removal of prior stabilizing agents by the DeconGel™. A second application of DeconGel™ was successful in reducing contamination levels in the track areas (Table 4). The effect of previous treatment processes on the efficacy of the tested gels in this demonstration is still unclear. Additional testing will be conducted at other DOE sites to better define the variables influencing the efficacy of the gels.

Table 4. Summary of DeconGel™ Results

Application	% Removed	
	Alpha	Beta
App. 1 All Surfaces	51%	58%
App. 1 Floor, Doors, Walls	53%	82%
App. 1 Tracks Only	49%	1%
App. 2 Tracks Only	38%	63%

Decontamination agents can be an effective means of reducing or eliminating contamination on building surfaces and equipment. This technology may improve worker safety and could reduce personnel protection equipment requirements. Decontamination agents have the potential to reduce the cost and accelerate the schedule for D&D by reducing contamination control and monitoring requirements before and during D&D.

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